UAV Image Recognition Technology and Applications in Transportation

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Abstract. In recent years, with the development of economy and science and technology, establishing a more intelligent transportation system is an effective way to solve the frequent traffic problems. Drones are widely used in intelligent transportation because of their compactness and flexibility, wide aerial view, and good real-time performance, etc. The use of drone image recognition technology has become an important means of solving problems such as traffic safety and traffic congestion. The purpose of the research in this paper is to summarize and prospect the future direction of UAVs in transportation.Firstly, this paper divides the application of drones in transportation into three directions, and combines the improvement narratives of drone image recognition technology based on transportation in recent years, which are (1) the application of drone images in strengthening road safety (2) the application of drones in precise violation detection (3) the application of drones in reducing traffic congestion problems. Finally, the above points are combined to look forward to the future development trend of UAV image recognition technology and its wider application in transportation.This paper concludes that drones have a very important role in establishing intelligent transportation, but there is still room for progress in improving image recognition technology.

Keywords: Unmanned Aerial Vehicle, Image Recognition, Road Security, Violation Monitoring, Traffic Jam

1 Introduction

The World Health Organization's latest Global Status Report on Road Safety 2023 shows that road traffic deaths have declined by 5% per year since 2010, and today 1.19 million people still die in road accidents each year. Through a study it can be found that today's population has grown more than the UN predicted in previous years [1], the world's population might reach 10.4 billion by 2080, and as the population grows the demand for vehicles is also increasing. Therefore, there are still many problems facing transportation, including how to ensure road safety, how to accurately conduct violation detection, and how to better clear traffic congestion.

In order to better solve traffic problems, collecting real-time traffic data has become the focus of researchers. Different from the traditional traffic data collection methods, such as GPS, cell phones, GIS, etc., UAVs have the characteristics of compactness and

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flexibility, wide field of view of aerial photography, and good real-time performance, etc. The traditional methods often have the shortcomings of fixed filming locations, which require great manpower and material resources, and are difficult to be used in remote or dangerous terrain places. For the traffic management department, quickly obtaining the video image of the location where the incident occurred is the key to solving traffic problems. However, if a comprehensive observation is required, such as overlooking the traffic environment around a certain location, or some places where the traffic police cannot reach quickly, then flexible drones are needed to assist in traffic management. Used in intelligent transportation systems are increasing in number, drones can achieve manned aviation is difficult to achieve high-altitude operations, but also to reduce the risk of human life subjected to.
The most obvious role played by drones in smart cities would be the monitoring and surveillance of traffic [2], as well as the prediction of traffic conditions,, including vehicle identification, tracking, counting, road conditions, and traffic accidents. Much of the work used in intelligent transportation today is based on traffic data and vehicle data captured by cameras mounted on drones. Such as identifying traffic violations helping accident scenes, managing traffic congestion etc [3, 4]. Nowadays a large number of transportation systems related to drones have been established [5], using drones are widely used in transportation.However UAV image capture is still impressed by some factors such as dynamic moving backgrounds and complex environments.

Recently artificial intelligence especially deep learning aspects are more widely used in UAV image recognition techniques [6], which mainly help to improve the accuracy of image recognition so that UAVs are less affected by adverse conditions. How to better solve traffic problems has been an important research direction in the world in recent years, which is of great practical significance. This paper starts from three aspects: road safety, violation monitoring, and traffic congestion. It summarizes how UAV image recognition technology can now help to deal with traffic problems and establish an intelligent transportation system. It also puts forward the development trend of UAV image recognition technology in dealing with these problems. It provides a reference for the use of drones in intelligent transportation.

2 Road Security

2.1 Testing of The Accident Scene

UAV image recognition technology in road safety includes the detection of accident scenes. Accidents are often sudden in nature. When an accident occurs, compared with the speed of manned transportation to arrive at the scene and detect the accident scene, the drone can quickly upload the image to the platform after recognizing it. This allows the relevant departments to be notified more quickly, ensuring that the time to deal with the accident is as short as possible. And through the drone to detect the accident occurred in the surrounding environment, the degree of damage to the accident vehicles and the degree of injury to the personnel. Judge how many vehicles and personnel should be used to help deal with the accident.

Accident scene detection is mainly based on the use of methods, systems and vision algorithms. In vision algorithms, researchers mainly improve the feature extraction capability of the algorithms by improving the bone neural network used in deep learning algorithms. Earlier captured UAV images have many problems in this regard such as some impacts in capturing the image such as shooting angle, height glare, etc. the accuracy of the UAV captured images is important for the subsequent advancement of image based accident proposals, systems, software tools and image processing methods.

Researchers have made many studies to optimize this aspect [7]. And recently there have been studies based on software for image processing enhancement, or improved image processing methods, as well as constructing accident scenarios [8]. As shown in the Figure 1, the model is mainly based on having the UAV take pictures with a given frame overlap parameter after running a certain trajectory on the accident scene to help the model create an accident dataset, which is refined by taking pictures of each given waypoint location.

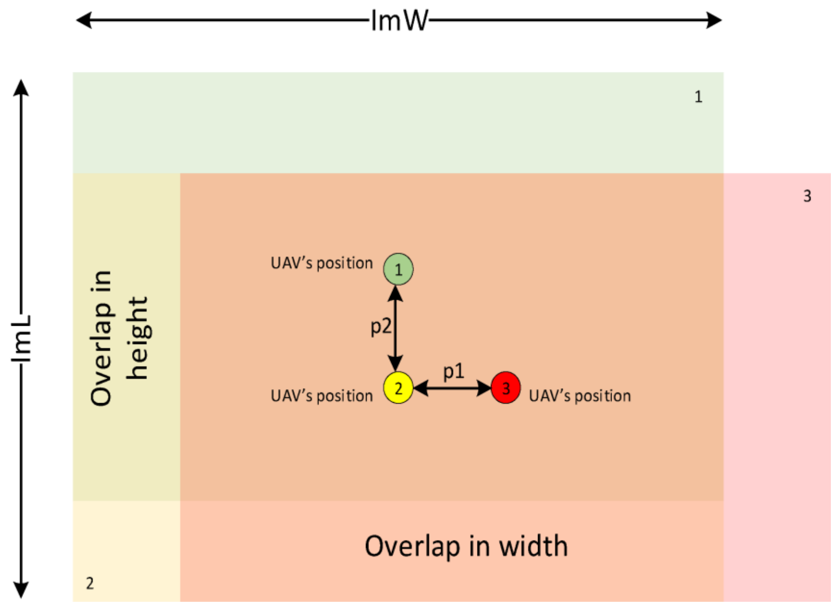

Fig. 1. Demonstration of frames overlapping in width and height

Frames overlap in width and height for the demo. Each color corresponds to a camera frame: green is the first frame, and the green circle with the number 1 is the center of the frame; yellow is the second frame, and the yellow circle with the number 2 is the center of the frame; and red is the third frame, and is centered on the red circle with the number 3. The accuracy of accident scene detection was made possible by these studies. And the process uses a panoramic segmentation method based on a deep convolutional model Switchable Wide Residual Network (SWideRNet) with axial attention. This method achieves better performance compared to the other three methods in the test of IOU values.

3 Detection Of Violations

Doing a good job of monitoring traffic violations is an important tool to help reduce traffic problems. Drones are used for many applications in traffic surveillance. Almost all drones require the use of a camera to perform a specific task, meaning that they all use drone image recognition technology. For example, in the use of license plate recognition, drones can use high-resolution cameras to determine whether a vehicle is in violation of the law, such as parking anywhere and driving on the pressure line, and can identify the license plate of the offending vehicle [9], and then impose a penalty on it. In the use of recognizing the condition of the vehicle, the UAV performs the recognition and then uses deep learning models. Such as the model of convolutional neural network and migration learning, to identify and classify the vehicle, to determine whether the vehicle meets the standards required by the state, whether there is illegal modification, or overloading, overweight behavior, etc.. In the application of facial recognition, the driver's behavior can be monitored to identify whether he/she has violated the rules and regulations such as dialing cell phones while driving and not wearing seat belts, and then identify the driver's information and then punish him/her.

There are some limitations in the aerial perspective of drones. UAVs usually shoot ground targets from a top-down viewpoint, and most of the images are small targets. Small targets have low pixel values, single features and little available information, which makes the target detection task difficult. Conventional target detection algorithms have limited ability to characterize single-layer feature maps in convolutional neural networks, which is difficult to cope with complex small targets in images, resulting in poor detection results. To address the problem of poor detection of small targets in unmanned aerial images, it is necessary to redesign and optimize the network structure, improve the feature extraction ability of the network, and enhance the robustness of the algorithm.

Due to the fact that UAVs are far away from the detection target when performing target detection at high altitude, there are significant differences in the size of the detected objects and there are problems such as the detected targets being blocked by objects. J. Sui, D. ChenX. Zheng and H. Wang proposed an improved algorithm BDH-YOLO based on YOLOv8s for small target detection at high altitude for UAVs [10]. Using the backbone network of YOLOv8s, a weighted bi-directional feature pyramid network (BiFPN) is combined with the backbone network to enhance the integration of multilevel features and obtain more multi-scale semantic information. Multiple downsampling in processing feature maps leads to a reduction in feature map resolution, which causes pixels on the feature map to overlap, thus losing a large amount of spatial information. introduces DyHead (Dynamic Head), a dynamic detection head that incorporates self-attention, to significantly improve the performance of the target detector by combining the three-dimensional perception capability of scale-awareness. spatial-awareness, and task-awareness.The framework of the algorithm is shown in Figure 2.

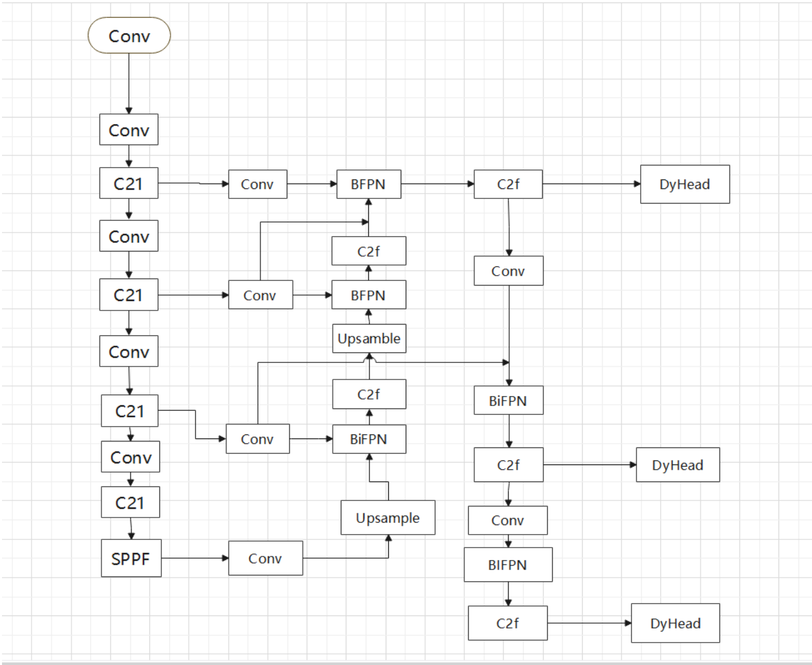

Fig. 2. Diagram of the overall structure of the BDH-YOLO

4 Solving Traffic Congestion Problems

Traffic jams are a common problem in urban transportation. It often causes prolonged blockages during the heaviest traffic times of the day. The complexity of urban roads makes it difficult to allocate human and material resources to solve the traffic jam problem. A drone overlooking the city can be used to create a traffic map of the city [11], marking the location of blocked roads and the extent of the blockage based on the images captured. Predicting the density of traffic flow can also plan more reasonable driving routes for drivers, so that traffic flow is evenly distributed on the road. It can also deal with serious blockages in a timely manner, helping to allocate transportation resources more rationally.

UAVs analyze the vehicular traffic flow by taking traffic images, mainly including traffic images, and road images, and by observing the density of the pixel point distribution. This process is generally done using deep learning based detection methods [7], which can be categorized into two-stage and single-stage detectors. Two-stage detectors first obtain a large number of regions of interest, usually using a region suggestion network, or a feature pyramid network (FPN), and then evaluate each ROI using a CNN. Unlike two-stage detectors, one-stage detectors cue ROIs directly from the image without the use of any region suggestion techniques, which saves time and can be used for real-time applications. Due to its complexity, the two-level detector has an advantage in terms of accuracy.

This is a framework for estimating traffic flow parameters based on advanced image segmentation techniques and basic traffic flow diagrams using aerial photographs of road traffic taken from a bird's-eye view to accurately measure the area occupied by different vehicles [12]. In contrast to the existing literature on traffic measurement, the framework presented in the figure does not require explicit vehicle classification and categorization counts, and only requires inputs in terms of percentage of occupied area.

5 Discussion

The recent applications of UAV image recognition technology in the field of transportation, especially in road safety, violation monitoring and solving traffic jams, have been heavily used. So vision algorithms and image processing are key elements in making progress in solving transportation problems with advanced applications of drones in extracting key information. This information can be used to enhance the accuracy of the algorithmic models.

Similarly, the bird's eye view angle of the camera provided by the UAV is considered important as it allows more accurate extraction of vehicle trajectories at lateral distances. Photographing road information overhead helps in creating accurate traffic maps in complex scenarios. This greatly helps to improve traditional methods and models used in traffic flow monitoring.

The real-time nature of drones also helps traffic problems to be solved in a more timely manner, reducing the loss of human and material resources.

Improvements over previous studies:

An accident scene construction model was developed for road safety mainly in the area of accident recognition. By constructing an accident scene from images taken at a certain trajectory and a certain number of frames, the amount of data from the accident scene is increased for model training. This increases the accuracy of the image recognition model.

For violation monitoring, mainly for small target recognition, a weighted bidirectional feature pyramid network (BiFPN) is combined with the backbone network using YOLOv8s. On the VisDrone2019-DET dataset, compared with the YOLOv8s model, the BDH-YOLO model improves the average accuracy (mAP@0.5) by 3 targets over other mainstream models.

For the traffic congestion problem, the framework presented in the paper.1 There is no explicit requirement for vehicle classification and classification counts. Only the percent occupied area is required as an input when estimating density and speed using the developed occupancy density and speed density base maps.

Transportation is an unavoidable problem in the development of society, and the help of drones on the city's intelligent transportation is very great, with the advancement of drone technology transportation system will also be better improved.Intelligent transportation systems combined with drones will become a major trend in the future, and in order to better solve transportation problems, researchers will better increase the clarity and resolution of images captured by drones and use them to build better recognition models and optimize recognition techniques.

6 Research Outlook

Image recognition algorithms have become an important part of UAV applications in intelligent transportation, and have received more and more attention from scholars. Target detection in the field of UAVs needs to take into account the accuracy of detection results while ensuring real-time detection. Although the existing algorithms have made some breakthroughs in detection accuracy and detection speed, there is still much room for improvement. In the future, it can be improved and optimized in the following aspects:

Multi-scale feature fusion: optimize the network structure and use a more efficient multi-scale feature fusion network. While ensuring the detection effect, avoiding the waste of arithmetic power and improving the detection speed of the algorithm.

Construction of dataset and data enhancement: At present, the dataset of UAV aerial images is smaller in size than that of natural images, and the scenes are relatively single. It is difficult to ensure high-quality feature extraction during the training process, which will directly affect the accuracy of the final prediction results. In the future, we can optimize the supplementary dataset to achieve the effect of data enhancement and improve the generalization ability of UAV target detection under complex background.

Reducing the cost of UAVs, we can increase the deployment of UAVs and establish a multi-UAV system to realize 360° images and improve the recognition rate of traffic problem images.

7 Conclusion

UAV image recognition is an important means to solve the tasks of road safety, violation monitoring and traffic congestion in the field of transportation, which has important research significance. Models based on drone image recognition technology will gradually become an integral part of transportation systems in the future

In this paper, we firstly synthesize the traffic problems into three aspects, mainly including road safety, violation monitoring, and traffic congestion. The application of image recognition technology in these areas and the current research status are introduced in detail, and the effects of old and new algorithms are compared. Some of the new techniques include new small target detection algorithms, accident scene reproduction models, and traffic flow analysis models. Separately, it is described which aspects have been optimized by these researches.

Finally, the factors of images captured by imaging UAVs are analyzed, and the possible future development trends of UAV image missions are looked forward, including how to better combine UAVs and other technologies, and in what ways to better optimize the UAV image recognition technology, so that the model can be better used in the transportation system. A reference is provided for related researchers.

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